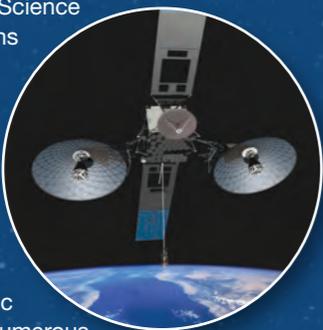




National Aeronautics and Space Administration

The **Flight Dynamics Facility** is a fully customer-funded provider of comprehensive flight dynamics services to space communications networks, science and exploration programs, and expendable launch vehicle providers. The FDF's professional staff of mission analysts, navigation engineers, and software and sustaining engineers demonstrates a proven record in support of numerous missions and diverse customers. Our customers include the Space and Near Earth Networks, Earth and Space Science Mission Operations Project Offices, JSC Human Spaceflight Program, KSC Launch Services Program and commercial ELV providers, operational robotic spacecraft, and numerous developmental flight projects. Missions that FDF supports, or has supported, include Aqua, Aura, SMAP, GPM, and LDCM; SDO, and GOES and TDRS fleets; LRO; Wind, SOHO, ACE, and DSCOVR; STEREO; MMS; Atlas V, Delta II, and Delta IV; ISS and Visiting Vehicles; and, EFT-1. Our strength lies in the diversity of the missions that we support and services we provide. The services include mission analysis; trajectory design; maneuver planning; operations planning; mission integration; navigation; real-time operations support; and, daily support of over 30 operational spacecraft. We have also supported non-traditional customers such as balloon gondolas and long-duration, high-altitude aircraft. The FDF is capable of providing 24x7 services during critical mission operations phases. Located at Goddard Space Flight Center as part of the Navigation and Mission Design Branch, the facility utilizes Goddard Mission Services Evolution Center ground system architecture with a virtualized computing environment. Risks to providing customer services and products are mitigated through a robust system design, which includes an alternate processing facility to ensure long-term system availability.



Our unique array of capabilities supports NASA, other U.S. Government organizations, private industry, and foreign space agencies. FDF software and sustaining engineers diligently design, engineer, develop, maintain, improve, and adapt systems and interfaces to ensure that all mission requirements are met. We have the analytical and engineering expertise, depth and breadth, and resources to accomplish the job throughout the entire mission lifecycle. FDF support is coordinated in an integrated approach to provide a total flight dynamics solution. Our goal is to provide flexible, valued-added support to our customers at a reasonable cost.



With over 40 years of experience and as a recognized leader in the field of flight dynamics, the FDF offers expertise, flexibility, and innovation in several key technical areas.

*No matter what your mission or flight dynamics requirements, the chances are excellent that the FDF can fulfill your needs on the way to total mission success.*

SPACE  
EXPLORATION  
AND  
UTILIZATION  
BENEFITS  
ALL



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NP-2016-4-412-GSFC

flight dynamics facility



# FLIGHT DYNAMICS FACILITY SERVICES

## Mission Analysis, Trajectory Design, and Maneuver Planning

Our branch is the world leader in innovative mission analysis, trajectory design, and maneuver planning expertise. As the branch's operational arm, the FDF utilizes these technologies and vast flight operations experience to support missions using a wide variety of trajectory and orbit concepts. Combined with an in-depth knowledge of network capability, the FDF offers expertise with a multitude of operations concepts, trajectory design, and maneuver planning strategies covering all mission phases from concept formulation through end-of-life.

We provide unparalleled analysis, mission design, and orbit maneuver support for missions such as the high-energy, multiple lunar swing-by WIND mission, as well as LRO, THEMIS, and ARTEMIS. They also include the high-energy, Sun-Earth libration point halo and Lissajous orbit missions such as ACE and SOHO, a class of mission types pioneered at Goddard. We have also successfully supported multiple payload constellations such as ST-5, STEREO, and THEMIS, trajectory redesigns such as the ARTEMIS mission, optimized transfer trajectories, and stationkeeping. We can help you research, plan and fly your mission, and our team of highly capable analysts and engineers will employ innovative approaches to meet your unique mission requirements and goals.

The FDF provides maneuver predictions utilizing high-fidelity propulsion system modeling and targeting techniques to derive predicted post-maneuver states for mission planning, and network scheduling and acquisition. We can support missions utilizing monopropellant hydrazine, hypergolic, and low-



thrust technologies. In addition, FDF provides post-maneuver definitive orbit determination solutions for science data processing as well as calibration of the propulsion system and monitoring propellant usage. The FDF supports over 250 orbit maneuvers each year.

## Navigation

The FDF provides navigation support for all mission phases and flight regimes, including launch and powered-flight, post-separation, orbit transfer, on-orbit, orbit adjust and momentum management, and re-entry. We routinely evaluate tracking system performance and certify new tracking capability; provide pointing information to multiple network elements for all flight phases; and, provide navigation support for missions in ballistic, low-Earth, geosynchronous, lunar, Lagrange, and heliocentric trajectories.

Our facility provides performance evaluation, calibration, and validation of SN and NEN tracking systems. The FDF also provides tracking data analysis for Goddard projects supported by other networks, e.g., the DSN, DoD C-band radars, and ESA.

The FDF ingests, processes, and stores numerous data types, including: S-band UDF; low-speed C-band; DSN S-band, X-band, Delta DORR; SN Ka-band for both SSA and MA services; GPS; NORAD B3; and, Differenced One-Way Doppler with simultaneous TDRS support. We have the expertise to incorporate and process new tracking data types depending upon the mission requirement.

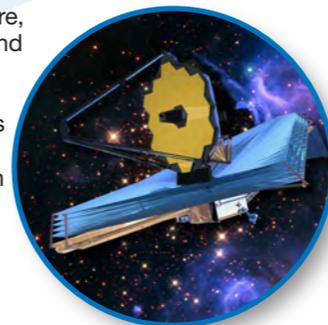
We employ state-of-the-art environmental models and space weather predictions to improve the fidelity of our analyses, predictions, and definitive orbit solutions, and investigate



emerging dynamical models that have the potential to further improve the results of our work. These include different techniques for evaluating the effects of the Earth's atmosphere, gravity models, and solar activity.

The FDF performs the following satellite navigation services:

- Navigation Analysis
- Definitive Orbit Determination and State Propagation
- Acquisition Data Generation and Transmission
- Planning Product Generation
- Maneuver Support
- Radiometric Tracking Data Evaluation
- Local Oscillator Frequency Evaluation
- RF Compatibility Test Support
- Certification of Network Tracking Assets
- Satellite Re-entry Predictions



## Expendable Launch Vehicles

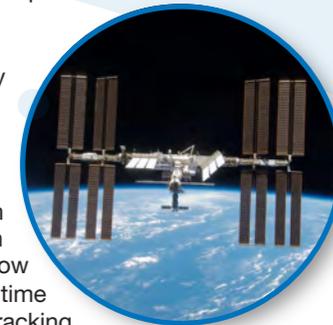
We monitor ELV performance, based on the nominal planned trajectory, by utilizing the vehicle's real-time guidance telemetry and predefined network assets during powered-flight. With this service the customer can receive real-time launch trajectory information, acquisition data support, and delivery of the actual payload orbital insertion state vector.

The FDF support capabilities for ELVs include:

- Supporting multiple launch vehicles, e.g., Atlas V, Delta II, Delta IV, and preparing for Vega and SLS
- Developing optimal acquisition strategies
- Supporting pre-mission testing and simulations to verify data formats and interfaces
- Generating pre-mission and real-time antenna

pointing acquisition data and planning products based on the planned trajectory

- Coordinating between tracking resources and the launch service provider
- Using in-house capabilities to support inertially targeted missions, i.e., with multiple trajectories depending upon liftoff time within the launch window
- Processing real-time launch vehicle tracking and telemetry
- Generating post-maneuver trajectory predictions based on upper stage burn modeling
- Providing real-time graphical and digital trajectory monitoring against the nominal predicted trajectory to show the predicted and commanded TDRS antenna pointing.



## Human Spaceflight

The FDF has supported human spaceflight missions dating back to the Mercury and Gemini Programs, all space shuttle missions, currently the ISS and Visiting Vehicles, and preparing for ISS crewed capsules and exploration missions. We have, or are currently supporting the following missions: ISS, ATV, HTV, Sierra Nevada DreamChaser, Soyuz, SpaceX Dragon, Dragon V2, Boeing CST-100 Starliner, Orbital/ATK Cygnus, EFT-1, and EM-1. This support varies by mission, but overall includes pre-mission and launch trajectory analysis, acquisition data generation and transmission to supporting sites, real-time monitoring of guidance data in support of contingencies, rendezvous maneuver support, backup navigation to JSC, and re-entry support.

Our certified team members support approximately 15 ELV missions and as many human spaceflight activities every year.